ROYAL ASTRONOMICAL SOCIETY.

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Rev. R. MAIN, Vice-President, in the Chair.

Charles Leeson Prince, Esq., Uckfield, Sussex;
Rev. Thomas W. Weare, Under-Master of Westminster School;
Charles Howell, Esq., Hove, near Brighton,

were balloted for and duly elected Fellows of the Society.

It was announced from the Chair that Miss Sheepshanks, of London Street, Reading, had presented to the Society all the astronomical and other scientific instruments which belonged to her late brother, the Reverend Richard Sheepshanks. This intelligence cannot fail to be gratifying, not merely to the personal friends of Mr. Sheepshanks, who cherish a lively remembrance of his many endearing qualities, but to all true lovers of astronomy throughout the country, who appreciate the unwearied devotion with which Mr. Sheepshanks laboured in promoting the interests of this Society. The intrinsic value of this munificent gift may be readily inferred from a recollection of the admirable judgment of Mr. Sheepshanks and his consummate skill in all that related to the theory and manipulation of instruments. It is scarcely necessary to add that the thanks of the Society were unanimously awarded to Miss Sheepshanks for these valuable and interesting memorials of her lamented relative.*

New Planet.

A new Planet (the forty-fourth of the minor planets) was discovered by M. Goldschmidt at Paris, on the 27th of May. The following positions were obtained by the discoverer:—

	M.T. Paris.	R.A.	Decl.	
	h m	h m s	° ′	
1857, May 27	11	15 15 58	−12 8	Merely approximate.
June 1	10 55	*a* − 3 53·8		

The star *a* is Lalande 28036. The planet resembles a star of the 10.11th magnitude. Two complete positions and elements of the planet will be found at page 253.

* A detailed list of the various instruments contained in this valuable collection will be given on a future occasion.— R. G.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of May, 1857.

(*Communicated by the Astronomer Royal.*)

Ariadne.

(In continuation of those sent last Month.)

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 11	9	50	6·9	13	8	35·85	102	38	48·12
13	9	41	14·5	13	7	35·12	102	26	20·20
14	9	36	51·4	13	7	7·83	102	20	19·90
18	9	19	38·2	13	5	38·01	101	57	55·02
19	9	15	24·9	13	5	20·64	101	52	46·23

Iris.

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 4	10	28	2·7	13	19	1·95	104	59	35·17
5	10	23	22·0	13	18	17·08	104	53	5·89
6	10	18	42·4	13	17	33·25	104	46	40·19
7	10	14	3·6	13	16	50·29	104	40	19·12
8	10	9	26·3	13	16	8·76	104	34	1·17
11	9	55	40·5	13	14	10·36	104	15	32·11
13	9	46	36·2	13	12	57·65	104	3	37·32
14	9	42	5·8	13	12	23·09	103	57	47·28
18	9	24	17·5	13	10	18·14	103	35	22·95
19	9	19	53·6	13	9	50·04	103	30	3·81

May 13.—The observed place in R.A. agrees exactly with the Ephemeris, and that of N.P.D. does so after having been increased by 5′.

Lætitia.

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 14	12	57	11·1	16	28	0·41	95	57	48·29
26	12	0	12·8	16	18	11·50	95	19	33·73
27	11	55	26·1	16	17	20·52	95	17	8·19

Observations on the Stars in the Nebula of Orion.

By Mr. Otto Struve.

(*Communicated by the Astronomer Royal.*)

"Being interested with the publication of M. Liapounov's paper on the nebula of *Orion* (*Monthly Notices*, March, 1856), I was induced last autumn to compare with the heavens the different catalogues of the stars situated in that nebula (Sir J. Herschel's, Lamont's, Bond's, and Liapounov's Catalogues), in order to ascertain the origin of certain discrepancies offered by them. The results of this investigation will be communicated to the astronomical world in a memoir that I am now preparing for publication, as an addition to that of M. Liapounov. But some results to which I was led will, I hope, appear to deserve the particular attention and future inquiry of astronomers established at stations more favourably situated for the observation of that object. For this reason I avail myself of this early opportunity to notify these observations to the Astronomical Society.

"Sir J. Herschel's Catalogue (no doubt the most complete, and at the same time the most systematically worked, that we possess) contains, in the *Regio Huygheniana*, besides the well-known 6 stars of the trapezium, 5 other small stars numbered by him 51, 57, 75, 78, and 88. When I first directed my attention to these stars, on the beautiful night of 1856, Oct. 30, I could well see all of them, excepting 78, that really appeared to be out of the reach of our refractor. The other four stars were estimated by me to be in the following order of brightness:—

88	magn.	12
51	,,	12, 13
75	,,	12, 13
57	,,	13

"It then immediately struck me that there was a sixth star *s*, nearer to the trapezium than any of the other stars, that appeared to have been overlooked by Herschel, if it has not been omitted by him for other reasons. On that night I estimated it brighter than 51, but not quite so bright as 88. By micrometrical measures I found its position with regard to *θ Orionis* $\Delta\alpha = -7''\cdot3$, $\Delta\delta = -27''\cdot6$.* On further inquiry it appeared that this star was not to be found in any of the other catalogues, excepting, perhaps, in that of Dr. Lamont, where a star (No. 28) is indicated approximately in the same direction from θ, but at somewhat too great a distance.

* It may be desirable to remark that this star *s* is different from the new star of M. Porro, mentioned elsewhere in the present number. The differences from *θ Orionis* of M. Porro's star are roughly $\Delta\alpha = -4''$, $\Delta\delta = -5''$.—[Editor.]

" Nine days later, on the 8th of November, *s* was hardly visible, while the other 4 stars remained nearly in the same order of brightness: however, it was still visible, and so it was Dec. 2; but at this date its brightness could by no means be estimated higher than 13·5, the extreme limit that I assign to stars visible with our refractor. Hence a variability of light was proved for this star.

" Afterwards, 1857, Jan. 20 and Feb. 21, no trace was to be seen of this star; but on March 1 it reappeared, and was estimated nearly as bright as 57. Bad weather prevented my continuing observations on the next following days until March 18. At this date *s* appeared in brightness between 88 and 51, but considerably nearer to 88; two days later, March 20, it was even brighter than 88. Since then it began to decrease. March 23, I found it nearer to 51 than to 57; March 24, it was certainly less bright than 57. Clouds prevented me from observing on the next following evenings; and when again the sky cleared up, the strong twilight had put an end to these observations.

" Starting from the magnitudes assigned above to the four comparison stars, we have therefore the following reduced magnitudes of *s*:—

1856, Oct. 30	*s* = 12·3	1857, March 1	*s* = 13·2
Nov. 8	13·5	18	12·1
Dec. 2	13·5	20	11·9
1857, Jan. 20	not visible.	23	12·7
Feb. 21	not visible.	24	13·2

" These numbers, being deduced from comparison with stars of nearly the same brightness, might be regarded as exact within the limits of the exactitude with which the relative brightness of the comparison stars has been estimated by me. But here arises a new difficulty; for there are strong evidences that those comparison stars are equally subject to changes of light.

" The first of these stars, that exhibited strong indications of a variable light, was 75; but it was not until the last day's observations that I could satisfy myself entirely on this point. On the evening of March 1 it was so feeble that it could only be recognised by glimpses, and was not to be seen steadily; March 18, it offered almost the same appearance, so that I noted that it was certainly considerably inferior to 57. On the contrary, two days later, March 20, it was brighter than 57, but less bright than 51. From March 20 to 23 it appears to have yet a little increased in brightness; for on the last day I noted that it was now nearer to 51 than to 57. On the following night, March 24, it was again less bright than 57. From these observations, I think, there cannot remain a doubt about the variability of light in this star, unless the two chief comparison stars 51 and 57 were not themselves subject to changes of light; but even in that case the great difficulty I had to see 75 in the nights of March 1 and 18, while

the other stars remained easily visible, would be a sufficient proof of its variability. From these observations the greatest changes of light of star 75 would, however, hardly exceed one magnitude; for it never was so feeble as to disappear entirely in our refractor (or less than 13·5), and never has been seen brighter than 12·5.

"Either 51 or 88 is equally subject to change of light. During the whole season 88 had taken the lead in the order of brightness of the indicated 5 stars of Herschel's Catalogue; but in the last night, March 24, there was no doubt 51 was far the brightest of them. I am not quite sure to which of those two stars to attribute the aforesaid change; but from the most noticed change of the relation of 51 to 57, I am inclined to think that 88 is the variable star.

"Of Herschel's star 78 I could not see the least trace, neither in the beautiful night of Oct. 30, nor in any of the subsequent nights, until March 20. This last date I thought I could see it by glimpses; but was not quite sure on this point. On the evening of March 24 it was distinctly visible, so that I was enabled to determine its position by estimation. Hence it appears that in the last period of my observations this star was on the increase.

"We have, therefore, amongst the 6 observed stars in the *Regio Huygheniana*, on a space of 3 to 4 square minutes, at least 4 variable stars; but I think the number of variable stars in the same region will yet be considerably increased by further observations. The sixth star of the trapezium, for instance, bears strong indications of variability. On former occasions I agreed perfectly with Mr. Lassell's remark, that this star was fully of equal brightness with the fifth star; but this year it appeared to me constantly inferior. Perhaps this variability will explain the circumstance, that this sixth star, even after its discovery by Herschel, could never be seen by my father in the Dorpat refractor, while the fifth star was regularly observed. Probably, also, two or three stars seen and measured by Mr. Lamont in 1837, will be found of variable light; for I do not think that stars, distinctly seen by the Munich refractor, should be entirely out of the reach of visibility at Pulkova, if they have not undergone considerable changes of brightness. Finally, perhaps some of the stars indicated, but rather suspected than observed, by De Vico, Bond, and others, in the immediate vicinity of the trapezium, might equally be found of variable light.*

"The existence of so many variable stars on such a small space in the central part of the most curious nebula in the heavens, must of course induce us to suppose these phenomena intimately connected with the mysterious nature of that body. But perhaps our knowledge of variable stars generally, and of minute stars especially, may not be considered at present sufficiently extended to admit conclusions of almost mathematical strength. Therefore,

* A letter from the Rev. W. R. Dawes on the detection of duplicity of a star in this nebula, published in the *Monthly Notices*, vol. viii. page 31, will now be read with increased interest and signification.—[Editor.]

we must proceed by steps. One of the first questions that presents itself must be, Is the space of frequent variable stars limited by the Huyghenian region, or does it extend over the whole nebula? To answer this question peremptorily, we do not as yet possess sufficient data. The relative magnitudes indicated in Mr. Lassell's excellent catalogue, compared with those observed by Liapounov in the years immediately preceding the period of Lassell's observations, offer throughout an almost perfect agreement; so that we must conclude that in the short interval of their respective observations, no material change has happened in the *mean* brightness of any of the stars that are common to both observers. The agreement is somewhat less complete if we compare Sir J. Herschel's Catalogue with those of Lassell and Liapounov; but the differences in the indicated magnitudes, if reduced to the same scale, are not so great as to exceed the limits of admissible errors of estimation. In one instance, however, I am inclined to suppose a considerable variability of light. The star, No. 20, of Lassell's Catalogue, seen likewise by M. Liapounov, is the only star observed by those two astronomers, that does not occur in Herschel's list ($\Delta\alpha = +\ 320''{\cdot}1$; $\Delta\delta = -\ 184''{\cdot}0$). It is hardly admissible to suppose that, with the extraordinary care expended by Sir J. Herschel in the preparation of his catalogue, a star should have been overlooked by him that was bright enough to be distinctly seen in the Kazan refractor; the more so, as this star is situated in a very remarkable part of the nebula, in the *Regio Subnebulosa*, near the vertex of the angle formed by the sudden turn to the south of the *Proboscis Major*. The supposed variability of light in this star is supported by the fact that during the last winter this star belonged to the most difficult objects discernible by the Pulkova refractor, and certainly was inferior in light to many other stars that had been out of the reach of the Kazan refractor.

"On the contrary, the comparison of Bond's Catalogue would have led to many extraordinary conclusions; but I do not think those conclusions of any weight; for it appears that the said catalogue is crowded with errors, and worked without any system. Apparently, the author has expended more care on the graphical representation of the nebula than on the construction of the catalogue.

"Admitting that the observed rapid changes of light of those minute stars are connected with the nature of the nebula, it might be presumed we should equally be able to observe changes in the appearances of the nebula, and the distribution of the nebulous matter. But observations of this kind are subject to so many illusions that we cannot be cautious enough with regard to the conclusions to be derived from them. I do not think the common way followed by astronomers in the researches of this kind, viz. to compare with one another graphical representations made at different epochs by different observers, will ever lead us to results that might be regarded as above all doubt. The optical

power of the telescope, the transparency of the atmosphere at different stations, the peculiarities of the eye of the observer, the degree of skill and experience in graphical representations of this kind, together with the influence of the imagination of the observer, form obstacles that it will ever remain difficult to remove if we proceed in this way. Perhaps, by continuing the same system during centuries, we might detect, if they exist, changes of a progressive nature; but we should never be able to ascertain changes that happen in short intervals. Now the observed rapid changes of light in the stars, must of course lead us to expect similar rapid, perhaps periodical, changes or fluctuations in the appearance of the nebulous matter. It is, therefore, to similar rapid changes that we have particularly to direct our attention; and we shall be much more able to ascertain their existence by comparative observations on the brightness and forms of some prominent portions of the nebula, than by general representations of it. We must as much as possible concentrate the observations on singular parts, and not extend them over the whole body at once. It is in this way that I have tried to proceed during the last winter, and I consider myself justified in saying that on different points I have been strongly impressed with considerable changes that have happened during the comparatively short period of my observations. Nevertheless, being fully aware to how many illusions similar observations are subject, I do not venture to regard these observations as positive facts, until they shall have found further corroboration, especially by observers placed in more favourable climates and provided with sufficient optical means for that purpose. With this view I beg leave to recommend to their attention the following parts of the nebula:

"1. The bay, that extends from the *Sinus Gentilii*, in the direction to the trapezium. This bay has been delineated for the first time by Dr. Lamont, and has never been seen by Sir J. Herschel (*Cape Observations*, p. 32 (69)). Last autumn this bay appeared to me quite as dark as the *Sinus Gentilii;* but in the month of March it was filled with nebulosity, very little inferior in brightness to the surrounding portions of the *Regio Huygheniana.*

"2. The nebulous bridge, that apparently crosses the *Sinus Magnus*, with a point of concentrated light in the middle. Herschel has represented this bridge; but perhaps not strongly enough, and certainly not far enough extended, and without the mentioned concentrated light. Lamont has only very feeble traces of it; Bond has not seen it at all; finally, Liapounov has given it in the shape of a promontory, with a strong concentration of light on its extremity. I have seen it during this winter, sometimes more resembling to Herschel's delineation; on other occasions, with the strong concentrated light, like Liapounov; but always extending considerably farther to, and nearly, if not entirely, approaching, the southern boundary of the *Sinus Magnus.*

"3. The nebulosity near and round the star 75 of Herschel's

Catalogue. This nebulosity appeared to me subject to considerable changes of brightness.

"4. A sort of narrow channel, that connects in apparently a straight line the black space round the stars 76, 80, and 84, of Herschel's Catalogue, with the northern border of the *Sinus Magnus*, where it has its mouth near to the outer extremity of the before-mentioned bridge. This channel, that never has been represented by any other observer, was distinctly seen on March 24; but I could not entirely satisfy myself if it was interrupted or not in the neighbourhood of the star 87. On former occasions, when I had very carefully reviewed this same portion of the nebula, I had never seen a trace of the channel. The space round the three mentioned stars appeared to me sometimes quite dark, sometimes filled with nebulosity; but even when this nebulosity was the strongest, it was regularly defined, and appeared throughout of an uniform light, without any gradation similar to that represented by Herschel.

"My journal contains yet some more indications of suspected changes, but in no other case, besides the four mentioned, do I estimate the suspicion strong enough to invite other astronomers to direct their particular attention to them. However, I may add, that the general impression I have derived from the observations of this year has been that the central part of the nebula of *Orion* is in a state of continual change with regard to the brightness in different parts of it. Even with the best definition of images, its appearances were to me on no evening entirely agreeing with those on the next or any other night. Perhaps it will save trouble to astronomers, not provided with great telescopes, if I remark, that for the greater part such changes in the gradation of light can only be seen with very high optical means. In my opinion refractors of less than 10 inches aperture, if not supported by an extraordinary state of the atmosphere, would hardly prove themselves equal to the task.

"1 *May*, 1857."

Letter from Mr. Bond, Director of the Observatory, Cambridge, U. S., to the Secretary.

"It affords me pleasure to communicate the following results of our experiments instituted at this Observatory for the purpose of delineating the positions of a group of stars by the aid of photography.

"On the evening of the 27th of April the actinic apparatus was affixed to the 23-feet equatoreal. The groups of stars to be experimented upon consisted of *Mizar*, second magnitude, its companion of the fourth magnitude, and *Alcor*, of the fifth magnitude. These were taken simultaneously by the collodion

process. The images were distinct, and, although covering some seconds of arc, were so perfectly symmetrical that they were capable of very nice bisection. On the following day they were measured in distance, by Mr. Alvan Clark, with a reading microscope, as follows:—

Mizar to *Alcor*.	*Mizar* to companion.	Angle at *Mizar* between *Alcor* and companion.
r d	r d	
14 304·5	0 109·2	
303·6	110·5	
303·5	110·5	
		° ′
303·0	110·3	75 55
303·6	110·3	76 05
14 303·6	110·2	76 00

One revolution of the micrometer-screw is subdivided into 360 parts.

"From these measurements of the photographic images we obtain

"*Mizar* to *Alcor* = 14r·8433; *Mizar* to companion = 0r·3061; distance of companion = 0·02062 of distance of *Alcor*.

"To reduce this to seconds of arc we have from the Greenwich catalogue:—

Diff. Right Ascension *Mizar* and *Alcor*	=	m s 1 19·67
,, Declination ,, ,,	=	′ ″ 3 40·3

which gives the distance of *Alcor* from *Mizar* = 707″·8 in an arc of a great circle, and the distance of the companion from *Mizar* 707″·8 × 0·02062 = 14″·6.

"The computed angle of position of *Mizar* and *Alcor* is 72°·0. Adding the difference of the angles of position of the companion and *Alcor*, we obtain for the angle of position of the former 72°·0 + 76°·0 = 148°·0.

"Struve's observations, 'Positiones Mediæ,' Introd. p. 215, are as follows,—

	Distance.	Angle of Position.
	″	°
1830·63	14·37	147·6
1840·77	14·35	147·7
1847·65	14·25	148·2
Mean	14·33	147·8

"The observations of Bradley and Herschel in the last century prove that there is very little, if any, relative motion of the two stars. Taking Struve's places as correct for the present epoch, we have the following comparison between the photographic angles and those derived from direct measurement.

"Angle of position and distance of *Mizar* (*ζ Ursæ Majoris*) and its companion:—

	Photographic.	Struve.
Angle of Position	= 148°·0	147°·8
Distance	= 14″·60	14″·33

"Whether this close agreement is to be attributed partly to accident must be determined from further experiments, but it may be well to state that from the manner in which they have been obtained there could have been no bias in the measurements favourable to the photographic results.

"Some six years ago we published in the *Boston Traveller* an account of our having obtained daguerreotype impressions of the stars *Vega* and *Castor* by the aid of the great refractor, but at that time it was found impossible to extend the process to stars of lesser magnitude. This was attributed to the want of sufficient susceptibility in the daguerreotype plates, and to deficiency of power and regularity in the machinery designed for giving to the telescope uniform sidereal motion. These deficiencies have been recently supplied, first, by the construction of a driving-clock on the principle of the 'spring-governor,' in which the rotary motion of the fly-wheel is regulated by an oscillating pendulum, which has been found, from several years' practical application, to be the most perfect regulator of rotary motion yet devised. A machine of this description has been adapted to the great telescope by those excellent mechanicians, Messrs. George Clark and Alvan Clark, jun., of East Cambridge, assisted by their father, Mr. Alvan Clark, sen.

"This point having been satisfactorily accomplished, we obtained the assistance of Messrs. Whipple and Black, whose skill as daguerreotypists is unsurpassed, and whom we knew to be deeply interested in the success of the experiment: it is to those gentlemen that we are principally indebted for whatever of success has crowned our efforts in the perfect delineation of stars of the lesser magnitudes.

"I should mention that a zero for angle of position is obtained with neatness and precision by allowing the star, after the first impression has been taken, to move forward by its diurnal motion, and then renewing the image on the same plate. The line joining these two images will represent the direction of the circle of declination. We have several series of *Mizar* and *Arcturus* taken in this way.

"P.S. — Since the above was written we have measured the distance between *Mizar* and its companion from plates taken on four different nights — the angles are all but identical — showing that the first measures were not the result of accident.

At the close of the meeting the Astronomer Royal made an oral statement respecting certain ancient eclipses which have recently engaged his attention. A few years ago he communicated to the Royal Society a paper on the eclipses of Thales and Agathocles which was published in the *Philosophical Transactions* of that body for the year 1853. The circumstances connected with both these eclipses are known to every reader of ancient history. The eclipse of Thales happened during the occurrence of a battle between the Medes and Lydians; and according to Herodotus, the combatants on both sides were so terrified by the spectacle that an immediate cessation of hostilities ensued, and peace was concluded between the two nations. The account of the eclipse of Agathocles which has been given by the ancient writers is also associated with a very remarkable incident. Agathocles having been closely blockaded in the harbour of Syracuse by a Carthaginian fleet, took advantage of a temporary relaxation of the blockade occasioned by the enemy going in pursuit of a relieving fleet of ships laden with provisions, and quitting the harbour of Syracuse he landed on the opposite coast of Africa, and laid waste the Carthaginian territories. It is stated that the voyage to the African coast occupied six days, and that an eclipse (which from the description was manifestly total) occurred on the second day.

The late Mr. Baily, in a paper published in the *Philosophical Transactions* for 1810, had come to the conclusion that the eclipse of Thales must have occurred in the year 610 B.C., but he found it impossible by means of the same elements of the moon's orbit to satisfy the conditions of the eclipse of Agathocles.

The object of the Astronomer Royal in the paper above mentioned was, by means of the improved state of lunar astronomy, to fix the precise time of the occurrence of the eclipse of Thales using for this purpose the eclipse of Agathocles as a critical eclipse and supposing the place of the moon's node to be liable to error. The conclusion at which he arrived was that an eclipse which occurred in the year 584 B.C., is the one referred to by Herodotus, and not the eclipse of 610 B.C., as Baily supposed.*

The subsequent researches of Mr. Adams on the secular acceleration of the moon's mean motion, and the publication of the Solar Tables of MM. Hansen and Olufsen, having led Mr. Airy to suspect that the groundwork of his previous calculation was imperfect, he proceeded to investigate the subject anew. On this occasion he employed in his researches (in combination with the eclipses of Thales and Agathocles) the eclipse of Larissa, to which his attention had been invited, first by Mr. Hind, and afterwards by Mr. J. Bosanquet. This eclipse is mentioned by Xenophon in the *Anabasis*, as having led to the capture by the Persians of a Median city which he calls Larissa. In the retreat of the Greeks on the eastern side of the Tigris, not long after the seizure of their

* Mr. Airy here stated that a similar conclusion had been derived by Mr. Hind from good elements.

generals, they crossed the river Zapates, and also a ravine or steep watercourse, and then came to the Tigris. At this place there stood, according to Xenophon, "a large deserted city called Larissa, formerly inhabited by the Medes; its wall was 25 feet thick, 100 feet high; its circumference 2 parasangs; it was built of burnt bricks, placed upon an understructure of stone 20 feet high. When the Persians obtained the empire [of the east] from the Medes, the king of the Persians besieged the city, but could not in any way take it, but a cloud covered the sun and caused it to disappear completely, till [*i. e.* to such a degree that] the inhabitants withdrew, and thus the city was taken.* Close to this city was a pyramid of stone, 1 plethrum in breadth, 2 plethra in height. Thence the Greeks proceeded 6 parasangs to a great deserted castle, by a city called Mespila, formerly inhabited by the Medes; the substructure of its wall was of squared stone abounding in shells; the king of the Persians besieged it, but could not take it; Zeus, however, terrified the inhabitants with thunderbolts, and so the city was taken."

The minute description here given by Xenophon has enabled Layard, Jones, and others, to identify Larissa with the modern Nimrûd, and Mespila with the Mosul of the present day. It is plain that the phenomenon to which the Greek author refers as having led to the capture of Larissa, was no other than a total eclipse of the sun.

The Astronomer Royal accordingly examined approximately all the eclipses which occurred within an interval of forty years, including the given period, and having selected two he computed them accurately, but found them inapplicable. He then tried another (556, May 19, B.C.) which he had previously passed over because he doubted its totality, and had the great satisfaction of finding that the eclipse, though giving a small shadow, was total, and that it passed so near to Nimrûd that there could not be a doubt of the eclipse sought.

Mr. Airy then proceeded to explain the method of investigation which he employed in the discussion of these ancient eclipses. A brief account of this method is given in an abstract of his paper on the subject which will be found at page 243. The conclusion to which he has been conducted by his researches, is that Professor Hansen's Solar and Lunar Tables very well represent the phenomena of the three eclipses of Agathocles (309, Aug. 14, B.C.), Larissa (556, May 19, B.C.), and Thales (584, May 28, B.C.), as far as we can interpret the historical account of those eclipses.

It may be stated that the remarks of the Astronomer Royal were illustrated by topographical sketches of the localities of the

* Ἥλιον δὲ νεφέλη προκαλύψασα ἠφάνισε, μέχρι ἐξέλιπον οἱ ἄνθρωποι, καὶ οὕτως ἐάλω.—*Anab.* lib. iii. cap. iv. A suspicion is thrown out in some editions of the *Anabasis*, that this may refer to an eclipse of the sun, but the passage seems to have been overlooked by Kepler (*Astronomiæ Pars Optica*), nor has Riccioli included it in the list of eclipses which he quotes from the ancient writers, in his elaborate work the *Almagistum Novum*.—R. G.

different eclipses, by which the audience were enabled to obtain a clear view of the historical circumstances connected with the subject.

On the Variable Star B. A. C. 3345 (R *Leonis*).

By Joseph Baxendell, Esq.

This star, to which the Astronomer Royal has drawn attention in the last number of the *Monthly Notices*, was discovered to be variable by M. Koch in 1782; but from the little attention which it afterwards received, it was long supposed to be a very slow-changing variable, and to have a period of many years' duration. Later observations have, however, shown that its period does not exceed 10½ months. It is the star named R *Leonis* by Professor Argelander, and is No. 25 of Mr. Pogson's very useful "Catalogue of Fifty-three Variable Stars" in the 15th volume of the *Radcliffe Observations*, where it is stated to have a period of 313 days, and to vary from the 5th magnitude at maximum to the 10th at minimum. Mr. Pogson remarks that "the maximum magnitude of this star is by no means regular, but the light at such times is vividly red," and that "the period is also rather irregular."

Since the beginning of the year 1840 I have occasionally watched this star, and my observations have afforded the following times of maxima:—

1840, May 23.	1853, March 16.
1848, December 12.	1854, January 27.
1849, October 15.	1854, December 6.
1852, May 7.	1855, October 13.

From these data I have obtained for the mean period, 312·23 days; and for epoch, 1851, July 3·58. Calculated from these elements the maximum for 1857 ought to occur on June 27. In the March number of the *Monthly Notices*, p. 149, Professor Argelander gives June 21 as the probable time of this maximum.

A projection of all my observations on the basis of a mean period of 312·23 days shows that R *Leonis* belongs to the list of variables, which increase in brightness more rapidly than they diminish, — the interval from minimum to maximum being about 146 days, and from maximum to minimum, 166 days. The mean maximum magnitude is 6·2, and the mean minimum, 10·5; the extremes in the former case being 5·9 and 6·5, and in the latter 10·0 and 11·2. It appears, therefore, that the irregularities in the magnitude at minimum are much greater than those at maximum.

The red colour noticed by Mr. Criswick and Mr. Dunkin is considered by Mr. Pogson to be most decided at the time of maximum brightness (*Monthly Notices* for December, 1856, p. 24). In my observations the colour, when noticed, has always been described as "deep reddish-yellow," or "yellowish red."

Manchester, May 19, 1857.

On the Effect of Local Attraction in modifying the apparent form of the Earth, and some Remarks on the Real Existence of Diversity of Form, independent of their Effect. By Lieut. J. F. Tennant, Bengal Engineers, F.R.A.S., First Assistant G. T. Survey of India.

"In a paper I sent some time ago to the Society, I entered on an examination of the practical value of the results deduced by Mr. Pratt from his 'Estimate of Himmaleyan Attraction,' and showed that he failed in satisfying the geodesical data of the great longitudinal series.

"I have since received a letter from Mr. Pratt pointing out that I have extended his result beyond the limit he intended it to have. The ellipse given there would appear to be only a section of the supposed protuberant surface on that arc. It is useless for geodesical purposes, and I think there is no evidence that it is a real form at all.

"If, moreover, we suppose it to start at the southern extremity, cutting the mean ellipse, it will lie entirely within the mean surface, and can in any case only cut that surface at one point. The estimated projection of the surface at its centre above its chord is not then a measure of its difference from the general surface, as the chords of the two surfaces will be totally different. An ellipse representing a protuberance would generally require to have the extremity of its major axis out of the equatorial point, and this would satisfy three arcs. Hence the error into which I fell in interpreting Mr. Pratt's ellipse.

"The letter to which I have referred has again drawn my attention to the paper in the *Philosophical Transactions;* and in endeavouring to account for results so unexpectedly large, I have been led to the conclusion, that with Mr. Pratt's Hypothetical Attractions a further and very sensible correction to the measured lengths would be needed, and to some result on the modification of the mean figure, by attracting masses which will, I trust, be considered interesting.

"It is sufficiently shown in Mr. Pratt's paper that the order of error arising from neglecting the consideration that the visible side is projected on an erroneous plane is rejectaneous. Indeed it will appear evident that the neglect of $\frac{d\,\mathrm{R}}{d\,\theta}$ in the expression

$$\frac{d\,s}{d\,\theta} = \sqrt{\mathrm{R}^2 + \left(\frac{d\,\mathrm{R}}{d\,\theta}\right)^2}$$

will be rejectaneous (in all cases where the attraction is not far more certainly known than from Mr. Pratt's formula,) in the following investigation.

"I purpose therefore assuming that the attraction of the Himmaleh may be sufficiently represented by a force varying inversely

as the chord of an arc drawn from the station perpendicular to the equivalent attracting prism (art. 50 of Mr. Pratt's paper) and, further, that it acts in the direction of the chord, which assumptions, while they have no sensible influence in modifying the attractions within the limits of the two arcs, are essential to the extension of the law farther from the prism.

"If, then, θ be the arc distance of any point from the prism, the deflection of the plumb-line would be

$$\frac{7235'' \cos \frac{1}{2}\theta}{2\,R \sin \frac{1}{2}\theta} = \varphi$$

or,

$$\varphi = \frac{7235''}{2\,R} \cdot \cot \tfrac{1}{2}\theta.$$

"Also $d\,s = R\,d\,\theta$.

"Therefore the extremity of $d\,s$ would be elevated by

$$-\tan \varphi\, d\,s = -\frac{7235 \tan 1''}{2\,R} \cdot R \cot \tfrac{1}{2}\theta \cdot d\,\theta$$

above its true place were the attraction eliminated.

"Hence,

$$d \cdot \delta R = -7235 \tan 1'' \cdot \cot \tfrac{1}{2}\theta \cdot \frac{d\,\theta}{2}$$

$$\delta R = 7235 \tan 1'' \int \cot \tfrac{1}{2}\theta \cdot d\,\theta$$

or if δR be in feet, R being miles,

$$\delta R = -\frac{38200800}{M} \tan 1'' \{\log \sin \tfrac{1}{2}\theta + C\}$$

"If δR be supposed to vanish when $\theta = \frac{\pi}{2}$ we shall have

$$\delta R = \frac{38200800}{M} \tan 1'' \{\log \sin 45^\circ - \log \sin \tfrac{1}{2}\theta\}$$

$$= \log^{-1} 2{\cdot}629863_0 \{9{\cdot}8494850 - \log \sin \tfrac{1}{2}\theta\}$$

"Now, taking R = 3960 miles, we should have at

Damergida	$\theta =$	13	55	$\therefore \frac{1}{2}\theta =$	6	57	30
Kalianpur	$\theta =$	8	10	$\therefore \frac{1}{2}\theta =$	4	5	0
Kaliana	$\theta =$	3	13	$\therefore \frac{1}{2}\theta =$	1	36	30

"Whence the radius vector would have been increased at

Damergida	by δR =	326·7 feet
Kalianpur	by δR =	425·4 ,,
Kaliana	by δR =	597·6 ,,

A

"Also, since

$$-\frac{38200800}{M} \tan 1'' \int_{\pi}^{\frac{\pi}{2}} \cot \tfrac{1}{2}\theta \frac{d\,\theta}{2} = 64{\cdot}2 \text{ feet};$$

this would be the increment of the radius vector from the antipodes of the centre of the prism to the great circle, whose pole is its centre, which is the origin of the quantities A.

"If these amounts A be the true increments of the radius, then the southern arc would require a correction of $-35{\cdot}3$ feet, and the northern of $-53{\cdot}9$ feet. Small as these are in comparison with the corrections necessary to make Mr. Pratt's attractions consistent with the general figure, they are far larger than those he has found in his paper.

"If we knew the true law of any attraction, we could assign φ as a function of λ and L, the geocentric latitude and longitude, and R_1 and s being measured to and on the apparent surface, we should have

$$d \cdot R_1 = \frac{d R}{d \lambda} \cdot d \lambda + \tan \varphi \sqrt{\left(\frac{d s}{d \lambda}\right)^2 \cdot d\lambda^2 + \left(\frac{d s}{d L}\right)^2 \cdot d L^2}$$

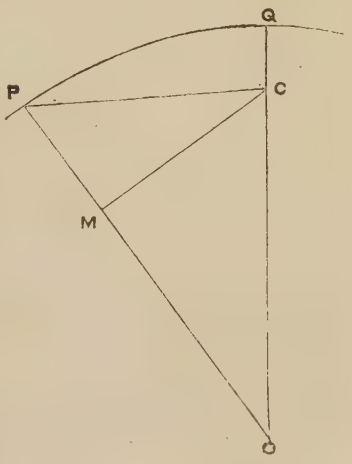
"One result of this perturbation of the radius vector is, that every mass whose tendency is to raise the horizon towards itself, will cause a sensible protuberance of surface, and each which depresses the horizon will cause a depression. This disturbance of the surface is independent of its *real* form. The mere superposition of the mass of the Himmaleh, as estimated by Mr. Pratt without any alteration in the rest of the surface, would cause the surface at Kaliana to appear depressed by nearly 600 feet.

"It is evident that we have here a form of protuberance which, while entirely the result of attraction, is insensible to levelling operations entirely. It therefore differs entirely from the physical changes which are appealed to for the probability of real changes. Every mountain mass, by virtue of its attraction, causes a protuberance which is removed by the elimination of the effects of the attraction; so does every mass internally of greater density than the average of the stratum, but all these changes are dependent on the local disturbances of the plumb-line, and are not included in the tacit definition given by Mr. Pratt. The only change reconcilable with his process of eliminating the effect of irregular disturbance is a form so limited as that it shall have the power of keeping the vertical always normal to its surface. The only form, I believe, which possesses this property is an ellipsoidal shell concentric with the general form, and which would, therefore, merge in it. A protuberance of 157 feet at the centre of an arc, $11\frac{1}{2}$ degrees in length, and merging in the figure at both ends, would not have this effect any more than a flat rounded hill.

"If I am correct in this belief, it is a necessary corollary that every apparent local protuberance will be an effect of the neglect in part, or *in toto*, of the irregular deflections of the plumb-line, and that did our imperfect knowledge permit us entirely to eliminate this source of error, we should have a figure of equilibrium as the result independent of any speculations as to the processes by which the present distribution of matter in the earth has been attained.

"I will conclude with an examination of the mass which, acting in the centre of an arc, would produce an elevation similar to that which is the asserted result of Mr. Pratt's investigations.

"I shall in this consider the surface as sufficiently satisfying the equation $ds = R\,d\theta$, where R is constant, and also that the mass causing deflection can be considered as concentrated in a point. The former hypothesis can cause no sensible error, and the latter will answer my purpose, which is (a rigorous investigation being out of the question) merely to show how small a mass will suffice to produce the result.



"In the accompanying figure let P Q represent the curbed surface; O its centre; O P = O Q = R the radius. Let C be the centre of the attracting mass, and C Q = r. Let the angle P O C = θ, the deflection at P = ϕ, and the deflecting mass which I will call the mass C = earth's mass $\times \frac{1}{m}$.

"The attraction of C on P : attraction of the earth on P : : $OP^2 : m\,PC^2$.

"Consequently the resolved portion in the direction of the tangent at P = attraction of earth on

$$P \cdot \frac{OP^2}{m\,PC^2} \times \frac{CM}{CP}$$

C M being perpendicular to P O; and the portion parallel to P O is rejectaneous compared with the earth's attraction.

"Now,

$$CM = CO \sin\theta = (R-r)\sin\theta$$

and

$$PC^2 = (R-r)^2 + R^2 - 2R(R-r)\cos\theta$$
$$= r^2 + 2R(R-r)\sin^2\tfrac{1}{2}\theta$$

therefore

$$\tan\phi = \frac{R^2(R-r)\sin\theta}{m\left\{r^2+2R(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}} = \frac{2R^2(R-r)\sin\frac{1}{2}\theta\cos\frac{1}{2}\theta}{m\left\{r^2+2R(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$

"Hence,

$$d\,\delta R_2 - R\,d\theta\tan\phi = -\frac{2R^2(R-r)\sin\frac{1}{2}\theta\cos\frac{1}{2}\theta}{m\left\{r^2+2R(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$

"Integrating, we find the value of

$$\delta R \text{ at } Q = \Delta R = \frac{2R^2}{m}\int_0^{\theta} \frac{2R(R-r)\sin\frac{1}{2}\theta\cos\frac{1}{2}\theta\,.\,d\theta}{\left\{r^2+2R(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$
$$= \frac{R^2}{m}\left\{\frac{1}{r} - \frac{1}{\sqrt{2R(R-r)\sin^2\frac{1}{2}\theta + r^2}}\right\}$$

or if ΔR be feet,

$$\Delta R = \frac{5280\, R^2}{m}\left\{\frac{1}{r} - \frac{1}{\sqrt{2\, R\,(R-r)\, \sin^2 \tfrac{1}{2}\theta + r^2}}\right\}$$

"Let

$$r = 52{\cdot}8 \text{ feet} = 0{\cdot}01 \text{ mile}$$
$$R = 3960 \text{ miles}$$
$$\Delta R = 157 \text{ feet}.$$

2θ = difference of latitudes of the extremities

$$= 11^\circ\, 27'\, 32'' \text{ or } \tfrac{1}{2}\theta = 2^\circ\, 51'\, 53''$$

"Then

$$\Delta R = \frac{5280\, R^2}{m}\left\{100 - 0{\cdot}0035728\right\}$$
$$= \frac{\log^{-1} 12{\cdot}9180093}{m} = 157$$

therefore

$$m = \frac{\log^{-1} 12{\cdot}9180093}{157}$$
$$= \log^{-1} 10{\cdot}7221096$$

"If we suppose this mass half the mean density of the earth, the sphere containing the necessary volume would be 1·351 miles in radius.

"Such a protuberance then might, in the case of the Indian arc, easily be produced by the elevated masses of Central India, whose greater volume would be counteracted by their diffusion of a large space.

"The attraction, then, of this mass on a station situated like Kalianpur, where $\theta = 20'\, 9''$ would be

$$\varphi = \tan^{-1} \frac{R^2\,(R-r)\, \sin 20'\, 9''}{m\left\{r^2 + 2\, R\,(R-r)\, \sin^2 10'\, 4''{\cdot}5\right\}^{\frac{3}{2}}} = 6''{\cdot}67$$

"This, in conjunction with the correction to the measured arc, would satisfy (even with Mr. Pratt's attractions) very closely the southern arc (Damergida to Kalianpur), considered as measured on the average spheroid. That, however, is accidental. Mr. Pratt's form does not, like this, meet the general ellipse in the ends of the arc.

"Since, then, we can account for apparent deviations of the surface of the earth from the mean form by, as I think I have shown, the effects of the attraction of small masses of matter; and we have, and can have, no evidence of the real existence of deviations which are independent of this source and real; it appears to me not consistent with the principles of induction to assign such as we may imagine we find to the latter cause.

"I have shown in my former paper that the ellipse given by Mr. Pratt for the Indian meridian is useless for geodesical purposes. I have now, I think, shown reason to believe that there is

no evidence which will warrant our considering that any real departure from the mean form exists.

"The following conclusion is not without its importance: It is impossible to place any dependence on a figure deduced from neighbouring arcs, even within their own limits, as considerable deviations may be caused by the attraction of small masses favourably situated; and the only figure of any geodesical or astronomical importance is that determined as usual from the consideration of a considerable number of arcs situated in various circumstances as regards sources of probable local disturbances."

Extract of a Letter from M. Schwabe to Mr. Carrington.

(*Translated freely.*)

"In the address of the President, contained in your *Monthly Notices*, the question is inadvertently asked, of what led me originally to undertake observations of the sun. It was in consequence of a representation of my old and valued friend Harding of Göttingen, who wrote to me that there was a great want of physical observations of the sun, that the subject presented an almost unworked field, and that labour therein might be rewarded by the discovery of a planet interior to *Mercury*. The communications of Harding and of a friend in Berlin led me also to inquire into the rotation of the sun, in which I found some difficulty from the instability of the spots. Nevertheless, I convinced myself that the opinion of Schroeter, that the spots had an independent motion, was unfounded, and that the apparent movement was attributable rather to the enlarging of one side and the filling in of the other side of a nuclear spot, whereby the estimated centre was shifted. My enumerations, however, early led me to notice a tolerably regular increase and decrease in the number of the spots, so that I may compare myself to Saul, who went out to seek his father's asses, and found a kingdom."

Report of the Syndicate appointed to visit the Observatory of Cambridge (*May* 30, 1857).

We extract the following passages from this Report:—

"The transit observations in the year 1856 amounted to 1865, and the circle observations to 1121.

"The total number of comparisons in R.A. (with the Northumberland equatoreal), is 695, and of those in N.P.D. 585.

" The number of occultations of fixed stars by the Moon observed in 1856 was 14.

" On May 30 Professor Challis informed Dr. Peters, the Editor of the *Astronomische Nachrichten*, that it was his intention to observe a limited number of the Minor Planets, and that he had selected the eight following: *Flora*, *Metis*, *Victoria*, *Themis*, *Proserpina*, *Bellona*, *Urania*, and *Leucothea*. A similar selection had previously been made at the Observatories of Washington and Altona, and several other Observatories have since adopted the same plan. It is expected that by this distribution of the work of observing the large number of these bodies now known, needless observations will be avoided, and each body will receive a due amount of attention.

" In July and August of last year repeated attempts were made by Professor Challis and Mr. Breen with the Northumberland telescope to find the planet *Leucothea* at the time of its opposition. The search proved ineffectual in consequence, most probably, of the invisibility of the planet from its small magnitude and low altitude. The efforts of the Berlin astronomers were alike unsuccessful.

" The observations of zodiacal stars and of planets on the meridian have suffered some interruption during the last half-year, owing principally to changes that have taken place in the personal establishment. Keeping still in view the formation of a star-catalogue, Professor Challis proposes to select for especial observation in future the stars that have been employed for comparison in equatoreal observations, for the purpose of preparing for the final reduction of the observations of planets and comets made in past years with the Northumberland telescope. Many of these stars are included in the list of zodiacal stars.

" The equatoreal observations of the minor planets were not restricted to the eight above mentioned, until the beginning of the present year. The others are still observed on the meridian near the times of opposition whenever they can be well seen, and in case ephemerides are provided either in the *Berliner Jahrbuch*, or by the superintendent of the *Nautical Almanac*. The planet *Neptune* is observed as in former years.

" From the commencement of the year to May 22 the number of transit-observations amounts to 430, and the number of circle observations to 287. In these are included 63 transits and 72 circle observations of the following objects: The Sun, *Hebe*, *Parthenope*, *Proserpina*, *Iris* and *Pallas*.

" The Northumberland equatoreal has been employed in the same interval upon the planets *Proserpina*, *Themis*, *Polyhymnia*, *Urania*, *Bellona*, and a new planet discovered by Mr. Pogson, at Oxford, on April 15, and upon two comets, one discovered on February 22 by Professor D'Arrest, and the other on March 18 by Dr. Bruhns. The latter comet has been identified with that discovered by Brorsen in February of 1846, which was diligently searched for by Mr. Breen on its expected return in 1851. It

now appears that the elements of the orbit computed from the observations of 1846, which extended over only two months, were considerably in error, and that the comet escaped detection in 1851, probably from the inaccuracy of the sweeping ephemeris.

"Occultations by the moon have been attended to as usual. The occultation of *Jupiter* and his satellites on January 2 presented peculiar phenomena, which Professor Challis observed with the Northumberland telescope under very favourable circumstances. The reduced times of observation, the physical appearances of the planet and satellites, and the jovicentric distances of the satellites calculated from the observed times, have been communicated to the Royal Astronomical Society.

"The equatoreal mounting of the Dollond 46-inch telescope, spoken of in the last Annual Report, has been completed by Mr. Simms, and appears to be satisfactorily executed. The apparatus was received so recently that there has not been time to place it on an equatoreal stand, or to form an opinion of the quality of the new object-glass."

On the Eclipse of Agathocles, the Eclipse at Larissa, and the Eclipse of Thales. By G. B. Airy, Esq., Astronomer Royal.

The author, adverting to his paper on the eclipses of Agathocles and Thales, in the *Philosophical Transactions*, 1853, in which the eclipse of Agathocles was used as the cardinal point of reference whereby to correct the motion of the moon's node, remarks that almost immediately after its publication there appeared reason to doubt the propriety of his tacit supposition that the longitude of the moon was sensibly correct. The first reason for extending the supposition of liability to error originated in Mr. Adams' theory of a diminished value of acceleration: other reasons appeared in the publication of Hansen's new Tables of the Sun, and (subsequently) in the preparation of Hansen's new Tables of the Moon. Finally, the author had been induced by the representations, first of Mr. Hind, and afterwards of Mr. J. W. Bosanquet, to examine into the time of the eclipse at the capture of Larissa, of which Xenophon has preserved a singular record; and, adopting Layard's and Capt. Felix Jones's identification of Larissa with Nimrûd, and using Capt. Felix Jones's map (with the correction of an important clerical error, which makes the longitudes too small by 1°), he had been enabled, as he conceives, incontestably to fix the date of that eclipse to -556, May 19. He therefore proceeded to treat the eclipses in the following manner.

There had been computed, with different elements for the places of the Sun and Moon, five different paths of the shadow

in the eclipse of Agathocles —309, August 14; four in that at Larissa —556, May 19; and four in that of Thales —584, May 28.

In order to reduce these, in the case of each eclipse, to a single result, the following method was used. The horary movements and parallaxes in all the calculations of one eclipse being sensibly the same, each shadow-path might be conceived as a function of the Sun's R.A. and N.P.D. and the Moon's R.A. and N.P.D. at a certain fundamental time for each eclipse. By the application of proper corrections to the Moon's R.A. and N.P.D. in every system of elements but one (Hansen's), all the shadow-paths were made functions of Hansen's Solar Elements, and of different lunar elements. And, measuring graphically the distance of each shadow-path from Hansen's shadow-path, that distance depended only on the difference of the corrected elements of the Moon in the compared shadow-path from Hansen's elements of the Moon. The distance, therefore, could be expressed by the sum of two terms, one a multiple of difference of R.A., the other a multiple of difference of N.P.D. By solution of equations the different multipliers were found, applying to each different eclipse. From these it was easy to express the shift in the position of the shadow-path in terms of changes of Moon's longitude and E.N.P.D.: and, finally, to express it in terms of an alteration in the coefficient of acceleration and an alteration in the motion of the Moon's node.

In proceeding to apply these numbers to the circumstances of the different eclipses, the author remarks that, on account of the extreme narrowness of the shadow and the definiteness of the locality where the eclipse was seen, the eclipse at Larissa ought to be taken as the cardinal eclipse. After discussion of the other eclipses, he arrives at the following conclusions:—

1. The eclipse at Larissa, —556, May 19, is established as a real eclipse at a well-defined point, and may be used for critical reference in deciding on the value of lunar tables as applicable to distant eclipses of the Moon.

2. Professor Hansen's Tables very well represent the phenomena of the three eclipses of Agathocles, Larissa, and Thales.

3. If any change in the elements of the tables is permitted, it must be in the nature of increase of the acceleration and increase in the argument of latitude in the distant ages.

4. It must now be understood that Agathocles passed on the south side of Sicily.

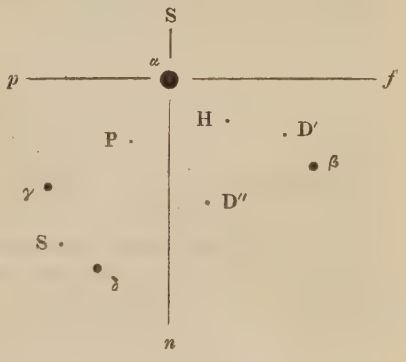
The author then remarks that the best prospect for further test of the Lunar Tables is to be found in the combination of the eclipse at Larissa with that at Stiklastad, A.D. 1030, Aug. 31 (*Astronomische Nachrichten*, Ergänzungs-heft, page 42): as, in both the shadows were very narrow, and the places of observation are perfectly definite; while their interval of time is very favourable for the separation of terms depending on the first power of the time from terms depending on the square of the time.

Discovery of a New Star in the Nebula of Orion.

(*Extract from a Letter addressed to Admiral Manners by M. Antoine D'Abbadie.*)

"M. Porro, our Parisian optician, has discovered a new star P in the well-known trapezium of *Orion*. It was first seen by him when trying his object-glass of 15 mètres focal length and 52 centimètres (or 20·5 English inches) in diameter. The eye-piece magnified 1200 times. The star P is certainly fainter than the stars D′ and D″. It was seen again by the same artist with his equatoreal of 4·4 mètres focal length, with an object-glass of 24 centimètres (= 9·45 English inches), and a power of 600; and lastly, on the 15th of last March, he saw again the star P in his larger refractor. The stars H and S were then visible, but D′ and D″ could not be seen. This was confirmed by another person not accustomed to observations, but who laid down at once the star P as in the accompanying sketch.

S ... Struve.
D′ and D″ ... Dumouchel.
H ... J. South.*
P ... Porro.



"As there was no ring-micrometer at hand and the faintness of the stars prevented illuminating the wires, no measures were taken, but M. Porro thinks that the relative declination of the star P is not so good as its relative R.A. The stars P, D′, D″, and S disappeared under a very faint illumination, H alone remaining then visible.

"It would, perhaps, be well to publish the above account, in order to get it confirmed by the owner of some powerful instrument.

"M. Porro has recently constructed a helioscope or telescope, so contrived as to allow observing the sun most conveniently and with any magnifying power. No dark glasses are used in the helioscope. The sun's spots appear like a spot of dark ground bared (*sic*) through a coating of snow, the sun's glare and heat being alike extinguished by this instrument, which cannot fail to be appreciated by all those who wish to investigate the physical peculiarities of the sun.

"*Königsberg*, 1857, *May* 21."

* The Editor gives Mr. D'Abbadie's plan of the trapezium, as sent in his letter, though he doubts the correctness of the position of the star H and its appended name; the more so as the well-known sixth star is omitted, which was first seen *by Sir John Herschel* while viewing the nebula *with Sir James South's refractor.*

Elements of Ariadne. By M. Pape.*

Epoch 1857, May 18·45901

M	=	315° 24′ 3″·5	
π	=	277 11 24·0	Mean Equinox 1857·0
Ω	=	264 44 32·8	
i	=	3 28 2·4	
φ	=	9 3 43·8	
Log a	=	0·342235	
Log μ	=	3·036654	
μ	=	1088″·065	

These elements were calculated from the Oxford Observations of April 15, 28, and May 6, and the Bilk Observation of May 18.

Occultation of 58 *Virginis, observed at Maresfield, in Sussex, June* 2, 1857. By Capt. W. Noble.

"The star disappeared instantaneously at $14^h\ 32^m\ 59^s{\cdot}4$ local sidereal time. Reappearance not seen. Telescope employed, my Ross equatoreal, 61 inches focal length; 4·2 inches aperture; power 74."

Occultation of α *Virginis, May* 6, 1857. By W. Huggins, Esq.

Disappearance,	9h 28m 54s	Local S.T.
Reappearance,	10 29 3·5	—

"The moon and star exceedingly well defined. The disappearance and reappearance both apparently instantaneous and quite normal. Telescope 5 inches aperture, 5 feet focal length; power 35.

"*Upper Tulse Hill.*"

* *Ast. Nach.* No. 1087.

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich, read at the Annual Visitation of the Royal Observatory, 1857, June 6.

The following are a few extracts from this Report :—

"The foundations of the new South-eastern Dome have been laid, and I trust that the building will be completed in this summer. It is in the place which I indicated in the last Report, at the south-eastern corner of the Record Room, but not in contact with the Record Room. For explanation of the design generally, I beg leave to refer to the model which the Visitors have seen. I may here state that the local position of the building compelled me to make the entrances into the three separate stories through the middle of the North Pier. A large stove is provided for the lower story, the draft of which passes underground into the chimney of the Record Room ; and I expect that this stove, by means of a trap in the first floor, will sufficiently warm and dry the second story. The dome will be drum-shaped, 29 feet in diameter inside, framed with vertical wooden standards upon horizontal curbs, and tied by diagonal iron hooping. It is to revolve on cannon-balls, and to be moved by toothed-wheel machinery carried by the dome, which acts upon a fixed rack of the wall-curb. The observing aperture will be 3 feet wide. The shutters will be two; a vertical wall-shutter, and a nearly horizontal roof-shutter, opening (for convenience of the mechanism) on opposite sides, each shutter opening independently of the other. Each shutter will carry a curved rack, to receive the action of a pinion carried by the solid parts of the dome. For the vertical shutter, I have made this rack jointed, and thereby I have been able to make the shutter flap close to the opening when it is closed, and flap close back to the dome-wall when it is opened, a condition which is not unimportant for preventing the wind from exerting any action to turn the dome. For the nearly horizontal shutter, I considered that the attempt to secure a shutter-movement of 180 degrees would introduce the necessity for the jointed rack, and would also require a complicated construction of counterpoises ; and I have therefore avoided these by causing the shutter, both in its closed and in its opened state, to take a position inclined to the horizon, its angular movement being about 140 degrees; thus it will scarcely feel the wind, and the inclination will not be visible to spectators below. Other points can be explained orally. * * *

"The arrangement of the Board of Longitude papers has at last been taken up seriously, under the immediate superintendence of Mr. Main. * * * *

"In regard to the Reflex-Zenith Tube, I described in my last Report to the Visitors the construction which I proposed for destroying the tremors of the quicksilver by suspending its trough by means of straps of vulcanized caoutchouc, so as to leave it the

utmost possible freedom of motion. The construction has been perfectly successful; the tremors are absolutely destroyed, and the star has been observed at all hours of night and day. It so happened that it was observed on the very day on which it passed with the sun. In the night-observations it is found that there is a perfectly steady nucleus, occasionally with rays twirling about it; the latter evidently arise from the deranged state of atmosphere, which seems usually incidental to a zenith-sector-room; to this I shall endeavour to give attention.

"The Altazimuth is in good order. A four-glass reflecting eyepiece has been made, which will tend to the facility and accuracy of observations at great elevations. I alluded in a preceding section to the cutting away of a very small portion of one of the rays of the three-armed pier which carries the Altazimuth. The quality of the brickwork is the best that I have ever seen, and not a single brick was disturbed beyond those actually removed. Yet the effect was to give the Altazimuth an inclination of about 23″. This inclination evidently depends on the elasticity of the brickwork. The angle between the axis of the vertical circle and the axis of general revolution, which at first was pretty exactly 90° 0′ 0″, has now become, by gradual change, about 90° 0′ 14″. The magnitude of the corresponding numerical correction to every observation of azimuth induces me to contemplate a re-adjustment of some of the mechanical connexions of the instrument.

"The Barrel Apparatus for chronographic record of transits has been in constant good order. To check the occasional tendency of the pendulum to describe an unreasonably large circle (from trifling inequalities in the maintaining power, which it is difficult to suppress entirely), I have mounted a slender spring, so as to produce, when the circle is large, a light friction. As every such friction is accompanied with force directed to the centre, it deranges the time of rotation. I have, however, planned a water-resistance which would be free from this objection, and which I may perhaps adopt in this instrument. A draftsman is at present employed in making plans of the barrel apparatus.

"The Galvanic Apparatus for clock movements is in the same state as last year, five clocks being in sympathetic movement in the Observatory, one at the Hospital Schools, and one in the North Kent Station at London Bridge. That for signals has received this slight alteration, that the pull of the Time Ball Detent now alters the connexions of four triplets of springs. Of these, one controls the communications with the Electric Telegraph Company's office at Lothbury; by which hourly signals are sent on various railways; the time-balls at the Strand, Cornhill, and Liverpool, are dropped; and the Post-office clock in Lombard Street is regulated. A second affects the communications with the South-Eastern Railway Station; by which hourly signals are sent on various lines in Kent, and the time-ball at Deal is dropped, and returns its signal to acquaint us with its successful drop. The third and fourth are reserved for the prospective wants of the

Royal Dockyards; they communicate with the Admiralty wire of the British Telegraph. The communication with the Post-office clock is remarkable. At $23^h\ 26^m\ 0^s$ of that clock a signal is given to Greenwich, the comparison of which with our clock acquaints us with the error of the Post-office clock. At $0^h\ 0^m\ 0^s$ of the Greenwich clock a signal is sent from Greenwich which mechanically adjusts the Post-office clock. At $0^h\ 26^m\ 0^s$ of the Post-office clock a second signal is given to Greenwich, by which the efficiency of the adjustment is shown. I am in daily expectation of the extension of this system to three other clocks. * * *

"For the new S.E. equatoreal, the support of the north or upper end of the polar axis has been received, and is planted within the walls of the building in a position convenient for raising it to its ultimate destination. It is one piece of cast-iron, extending from about 18 inches below the floor of the room to the polar point; it weighs nearly 5 tons, and is considered to be a good specimen of Messrs. Ransomes' excellent castings. The base of the north support will be tied to the south support by horizontal iron rods under the floor. The two end-frames of the polar axis are prepared; a portion of one side of the upper end-frame is cut away, to permit uninterrupted vision as far as the pole. For moving the polar frame in right ascension, there will be an hour-circle moved by clock-work, similar to that of the Northumberland telescope, to which the polar frame may be clamped at pleasure. This hour-circle is to have a graduation at its edge to be viewed by a fixed microscope, and a graduation on its plane to be viewed by microscopes of the polar axis. The clock-work is to be driven by water power, derived from the supply-pipes, and acting by a reaction machine, as at Liverpool. I expect that, with a compensation-pendulum, with Sieman's chronometric governor, and with a proper water-resistance, as I have suggested above, I can give extreme accuracy to the motion in right ascension. For fixing the polar frame in hour-angle when transits, &c., are required, I propose a clamp independent of the hour-circle. The polar frame is to be entirely of iron, essentially on the principle of the Northumberland frame, but differing in several details, which will be best seen in the model. The declination-axis will be excentric, as explained by me last year. The clamping circle will be most conveniently carried by the polar axis, but the declination circle will be carried by the telescope, and will be viewed by two or more inclined microscopes, whose eye-ends are very close together, and very close to the pivot of the declination-axis. I anticipate that in this way the use of the declination-microscopes, ordinarily so troublesome, will be made comparatively easy. The illumination, I believe, can be conveniently thrown down the tubes of the microscopes themselves. The upper pivot of the polar axis and one pivot of the declination-axis are to be perforated for gas-pipes, and thus gaslight will be carried to every part of the frame where it may be required, even to the eye-end of the telescope.

Those persons only who have used both oil lamps and gaslights under similar circumstances can fully appreciate the enormous advantage of this arrangement. Rings for galvanic contact will be mounted on the pivot of the polar axis, and on one pivot of the declination-axis, and thus the chronographic system, and possibly the sympathetic-clock system, will be carried to the eye-end of the telescope. The telescope tube will probably be of wood. This account, with inspection of the model, will perhaps give the Visitors a clear idea of my proposals regarding the equatoreal mounting. All this work is advancing in some degree, but there is still one important drawback; I have not yet received the object-glass. Messrs. Merz have not made a new object-glass to their satisfaction; they retain, however, the first in readiness, and can at any time transfer it for temporary use, so that I consider myself justified in making every possible preparation of mounting.

"*Astronomical Observations.* — The meridional system is sacredly preserved. Each star of a large clock-star-catalogue is observed, if possible, twenty times in three years; some stars are observed for refraction; some as having been compared with the moon; some on suspicion of proper motion, &c. The moon is observed at every opportunity, without exception. The sun and planets are observed at every opportunity, except on Sundays, and except when they pass later than 15^h in the morning, in which state the large planets only are observed, and only when the moon also is to be observed. The transits have been observed almost entirely by the chronographic method, except for the close circumpolar stars.

"The whole number of meridional observations from 1856, May 19, to 1857, May 23, is as follows:—In the department of transits: Observations of transits (reckoning two limbs, or two methods of observation by ear and by touch, as two observations), 4169; observations of collimator, by the telescope of the transit-circle, 311 pairs; observations of transit-wires by reflexion, 310; observations of one collimator by the other, 52. In the department of zenith-distances (reckoning two limbs, or a combination of direct observation with reflexion observation, as two observations, and including the observations of the wire by reflexion), circle observations of all kinds, 3663. * * *

"With the altazimuth, the moon has been completely observed on 198 days. This gives 15·8 per lunation. With the transit-circle the number of complete observations is 98, giving 7·8 per lunation. Of the observations with the altazimuth, 0 are on days when the moon passed between 0^h and 1^h of solar time, 3 when between 1^h and 2^h, 7 when between 2^h and 3^h, 3 when between 21^h and 22^h, 5 when between 22^h and 23^h, 0 when between 23^h and 0^h. There are no corresponding meridional observations. The whole number of separate observations of the moon and stars is 1058, and the whole number of observations of the collimator, 812.

"A series of observations has been made for ascertaining any deviation from circularity in the form of the pivots of the vertical circle, but no sensible fault was found. * * *

"*Magnetical and Meteorological Observations.*—No change is made in the system of observations; photographic self-registration being applied to the principal magnetical and meteorological instruments, pencil self-registration being applied to the wind and rain, and eye-observations being intermingled for zeros. Commencing with 1856, August 25, the thermometers in the magnet-boxes have been read at twenty-four consecutive hours once in every week, with the view of obtaining bases for complete reduction of the observations. The regular observations of the maximum and minimum thermometers in the Thames have been interrupted, as has been stated above, but I hope that arrangements may be made for their restoration. * * *

"Mr. Main's examination of Bessel's Refraction Tables, to which allusion was made in the last Report, is completed; it shows that the correction required, though small, is distinct. The temperature coefficient can scarcely be improved.

"The account (by myself) of the construction of the national standards of length is completed.* Some supplementary works relating to the equipment of the Exchequer Office still require attention.

"The British Government had for some years past contributed by pecuniary grants to the preparation of Professor Hansen's Lunar Tables. In the last winter they undertook the entire expense of printing a large impression of the Tables. The reading of the proof-sheets (a very considerable labour) has been effected entirely at the Observatory. I may take this opportunity of stating that the use of these Tables has enabled me, as I think, incontestably to fix the capture of Larissa to the date B.C. 556, May 19. This identification promises to prove valuable, not merely for its chronological utility, but also for its accurate determination of an astronomical epoch, the point eclipsed being exactly known, and the shadow having been very small. Several calculations have been made in reference to this and the two other ancient eclipses (of Agathocles and Thales), which I am now preparing to combine in one system of calculation."

Formulæ of Navigation and Nautical Astronomy. Arranged by Capt. Charles F. A. Shadwell, R.N., C.B. London, 1856.

These formulæ are exhibited on a series of twelve cards, enclosed in a pocket-case. Each formula is accompanied by an explanatory statement which is in most cases illustrated by means of a simple diagram. The selection of formulæ includes all those which are required for the solution of the working problems of

* A paper on this subject by the Astronomer Royal has been recently communicated to the Royal Society.—R. G.

navigation. To those who prefer the use of algebraic expressions to the diffuse language of a verbal precept, this publication will, no doubt, prove very serviceable; while others may be stimulated by it to extend their acquaintance with the processes of mathematical science, which would give them a mastery over the formulæ otherwise unattainable.

Dr. Rudolph Wolf, of Berne, in a letter to the Editor of the *Astronomische Nachrichten*, mentions that he has prepared for the press a paper on the Solar Spots, which will shortly appear in a Zurich periodical. This paper will contain a catalogue of 1131 observations of the solar spots by Staudacher of Nürembürg, extending over the period included between the years 1749 and 1799. From an examination of this catalogue, Dr. Wolf obtained the following results exhibiting the relative numbers of spots for each of the various years to which the observations refer.

Year.	Rel. Number of Spots.	Year.	Rel. Number of Spots.	Year.	Rel. Number of Spots.
1749	31·9	1766	16·1	1783	10·9
50	34·6 Max.	67	16·6	84	2·2 Min.
51	19·4	68	26·1	85	8·9
52	16·4	69	42·5 Max.	86	30·4
53	11·3	70	39·7	87	46·4 Max.
54	2·2	71	36·6	88	45·3
55	0·0 Min.	72	24·6	89	39·4
56	6·4	73	16·0	90	37·6
57	8·2	74	11·0	91	22·8
58	22·2	75	5·8	92	21·7
59	24·0	76	0·0 Min.	93	17·0
60	25·1	77	39·3	94	0·0
61	37·5 Max.	78	49·9 } Max.	95	2·0
62	25·3	79	49·6 }	96	12·0
63	18·7	80	36·3	97	0·0
64	19·1	81	35·2	98	0·0
65	11·5 Min.	82	14·3	99	0·0 Min.

Dr. Wolf states that the same publication will contain a series of very careful observations of the solar spots, by Zucconi, for the years 1754–57, from which he has deduced the following relative numbers:—

Year.	Rel. Number of Spots.
1754	9·9
55	5·2
56	6·7
57	19·7

Both series of observations, Dr. Wolf adds, corroborate the

conclusion arrived at by him in 1852, which placed the epoch of minimum in the year $1755 \pm 0^{\cdot}5$.

Elements of Planet (44). By M. Pape.*

Epoch 1857, June 15·5. M.T. Berlin.

M	=	68° 40′ 46″·2	
π	=	118 48 14·4	Mean Equinox 1857·0
Ω	=	127 5 57·5	
i	=	3 53 26·1	
ϕ	=	26 57 40·8	
Log a	=	0·427627	
Log μ	=	2·908567	

These elements were calculated from two Vienna observations of June 9 and June 12, and from a Bonn observation of June 15. The following are the two last-mentioned of these observations:—

			R.A.		Decl.	
	h m s		° ′ ″		° ′ ″	
1857, June 12	11 2 46·9	Vienna M.T.	226 13 13·8		−11 51 11	
15	10 11 51·0	Bonn M.T.	225 50 57·6		−11 50 43·3	

M. Pape has also calculated an ephemeris of the planet extending from June 25 to July 23.

New Comet.

The following telegraphic dispatch, announcing the discovery of a new comet at Göttingen by M. Klinkerfues, was received at the Royal Observatory, Greenwich:—

"A comet discovered by M. Klinkerfues at Göttingen.

Göttingen Mean Time.

June 22, $13^{h}\ 28^{m}\ 6^{s}$

Right Ascension 55° 6′

Declination 39°

Professor Challis has forwarded the following observation of the comet made at Cambridge:—

1857, June 24, $13^{h}\ 48^{m}\ 3^{s}\cdot1$ G.M.T.

R.A. $3^{h}\ 40^{m}\ 10^{s}\cdot95$

N.P.D. 48° 0′ 24″·9

* *Ast. Nach.* No. 1092.

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